LAMINATED ROOT ROT

A Guide for Reducing and Preventing Losses in Oregon and Washington Forests

Forest Service—USDA
Pacific Northwest Region

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James S. Hadfield and David W. Johnson [1/]
U.S. Forest Service—Pacific Northwest Region
Forest Insect and Disease Management
State and Private Forestry

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1/ Now located at U.S. Forest Service—Rocky Mountain Region Lakewood, Colorado.

Preface

This guide for reducing and preventing losses caused by laminated root rot has been prepared specifically for foresters and others concerned with the practice of forestry in Oregon and Washington.

The information presented was compiled from several sources and represents more than 40 years of research and observations by forest pathologists in the Pacific Northwest. Some of the advice presented is based on research which has not been completed. The guide will be revised periodically as new information becomes available.

The Problem

Laminated root rot, caused by *Phellinus* (*Poria*) *weirii* (Murr.) Gilbertson, is one of the most damaging and difficult diseases to control in Pacific Northwest conifer forests. It is widespread, occurring throughout the range of Douglas-fir in Oregon and Washington. Douglas-fir is the most important host, but nearly all conifers appear to be susceptible to attack to some degree. In the Douglas-fir forests of western Oregon and Washington, laminated root rot has been estimated to cause an annual loss of 32 million cubic feet of timber. In British Columbia, annual losses to laminated root rot are estimated to exceed 37 million cubic feet. Trees of all ages and sizes are susceptible to infection, but damage is most obvious in stands 20 to 150 years old.

Laminated root rot can be considered a disease of the site. Because of its persistence and spread from one rotation to the next, the fungus has potential for greatly reducing site productivity. Projections of forest productivity in the Douglas-fir region must account for the effects of laminated root rot; otherwise, the estimates will be unrealistic.

Damage can be reduced by appropriate treatments; conversely, damage can be increased by some actions.

Recognizing The Disease

Recognition of the signs and symptoms of laminated root rot is essential to reducing losses. If foresters do not recognize the disease, they may not apply appropriate treatments.

Laminated root rot centers appear as patches of dead and dying trees. West of the crest of the Cascade Range the infection centers are usually smaller than 1 acre; east of the Cascades, they frequently encompass more than 1 acre.

The appearance of laminated root rot centers varies with stand age and tree size. Seedlings only 1 or 2 years old are susceptible to infection, but the disease usually does not kill trees until they reach 10 to 15 years of age. In sapling stands, the disease often appears to affect scattered individual trees rather than groups of trees. Infected saplings usually die standing because they do not have enough crown weight to topple in spite of the decayed roots; also, they are killed quicker than larger trees.

The disease creates understocked, roughly circular openings in pole-size and larger stands. The typical active disease pocket contains trees in several stages of deterioration, varying from largely decomposed snags and windthrows to trees with fading crowns. In contrast, in patches of bark beetle kill all trees appear to have been killed at about the same time. Patches of windthrown and leaning trees oriented in several directions are good indicators of laminated root rot (fig. 1). In contrast, in blowdown areas where root rot is not involved, the downed trees are usually oriented in the same general direction. When infected trees fall, the decayed roots are often broken off close to the root collar, forming

Figure 1. Root disease center caused by *Phellinus weirii,* in a pole-size Douglas-fir stand in western Washington. Note numerous windthrown trees.

Figure 2. Uprooted Douglas-fir exhibiting "root ball".

Figure 3. Cross-section of an infected Douglas-fir stump showing the characteristic red-brown, crescent-shaped areas of incipient decay caused by *P. weirii.*

"root balls" (fig. 2). The root balls are especially helpful for diagnosing laminated root rot because few other root diseases cause this symptom. Callus tissue may form on the living ends of large roots that have been decayed for some time before the trees are windthrown. Brush and herbaceous plants frequently thrive in older infection centers in response to the increased amount of sunlight penetrating the stand canopy.

Crown symptoms of infected trees are variable and may not become noticeable until 50 percent or more of the root system has been destroyed. Root-rotted trees may be windthrown before crown symptoms appear. Reduced terminal growth is usually the first crown symptom. The crowns become thin, ragged, and yellow in the final stages of tree decline. A "distress" crop of abundant, smaller-than-normal cones may be produced. These crown symptoms are not always indicators of laminated root rot. They can also be produced by other root diseases, root-feeding insects, or animal damage.

The disease symptoms may not be apparent in infected overmature stands of Douglas-fir, especially if trees have not been killed for many years. When the infected large trees are cut, stained and decayed wood will be seen in the stump.

Laminated root rot can be most readily identified by the characteristic appearance of the decayed wood. The early stage of wood decay is reddish-brown to brown, appearing as streaks or broad bands on longitudinal sections of the butt and main roots and as circular, crescent, or irregular-shaped areas on cross sections (fig. 3). The stained wood fades within a few days after the wood has been exposed. Typical advanced decay can be found on the exposed ends of broken roots or by cutting into the bases of standing dead trees. The decayed wood is laminated and pitted. The wood separates by annual rings. The light yellow-brown sheets of decayed wood contain numerous oval pits about 1/2 millimeter wide and 1 millimeter long (fig. 4). Thin velvety

Figure 4. Advanced laminated decay caused by *P. weirii.* Note the separation of the annual rings and small pits in the wood.

Figure 5. Setal hyphae within *P. weirii* decayed wood look like reddish-brown whiskers.

layers or sparse tufts of reddish-brown mycelium can usually be found growing between the laminated sheets of decayed wood. With a hand lens, this mycelium, which is called setal hyphae, looks like reddish-brown wiry whiskers (fig. 5). Thin cinnamon-brown mycelial crusts often form on exposed ends of broken and buried roots with advanced decay. In the final stages of decay, the wood becomes a loose, stringy mass that disintegrates, leaving hollows in the butts of affected trees.

Laminated root rot may infect and kill small trees with small diameter roots without causing laminated decay.

The disease can be identified on living trees by exposing roots near the root collar and looking for gray-white to light purple mycelium on the surface of roots. It forms a continuous sheath around infected roots. The reddish-brown setal hyphae can be seen mixed within the mycelium (fig. 6). Unlike common molds, which sometimes grow on the surface of tree roots, the mycelium of *P. weirii* penetrates the bark tissues and cannot be easily rubbed off. Brown crust-like mycelium can often be found in the crotches of roots.

The fruiting bodies of *P. weirii* are brown crusts with tiny pores that usually form on the lower sides of windthrown trees and exposed roots in late summer and early fall. They vary in length from a few inches to several feet. The fruiting bodies, lying flat against the bark, are inconspicuous and are not produced frequently enough to be considered useful for diagnosis.

Aerial photography has been used to detect laminated root rot centers with accuracy only near the crest of the Cascades. The centers appear as unstocked irregular-shaped openings with white margins (fig. 7). Aerial photography has not been a reliable method for detecting laminated root rot in coastal forests.

Figure 6. *P. weirii* mycelium on the surface of the bark at the base of a small Douglas-fir.

Figure 7. Aerial photo (Scale 1:8000) showing openings caused by laminated root rot in a mountain hemlock stand near the crest of the Cascades.

Damage

Laminated root rot is most destructive as a tree killer and contributor to windthrow. In addition to the harvestable volume killed directly, potential future volume is lost when young trees are killed before they become large enough to harvest. *P. weirii* usually does not extend more than 5 to 8 feet above ground in living trees, so butt rot losses are much less important than tree killing. Indirectly, the disease contributes to losses caused by bark beetles which are attracted to trees weakened by root rot or recently windthrown. The trees weakened by root rot may serve as brood trees for bark beetles that can spread to nearby healthy trees.

In young stands, damage increases in proportion to stand age as the disease spreads and infection centers become more numerous. The number of trees affected double about every 15 years after the disease first becomes apparent.

Potential for damage is greatest where susceptible tree species are growing in the presence of large volumes of buried infected wood from the previous stand. In these situations, the disease will gradually spread and by the end of the rotation will greatly reduce the volume that could have been grown on the site. The disease will be at least as destructive in the current rotation as it was in the previous rotation if infested sites are regenerated with highly susceptible tree species.

Disease Development

The mycelium of *P. weirii* can survive in resin-impregnated tissues of large roots and stumps in the soil for 50 years or more after the trees have been cut or killed. The resin does not form an impenetrable wall to contain *P. weirii,* but it does prevent rapid invasion of the tissues by other wood-inhabiting organisms that could replace *P. weirii.*

Laminated root rot begins to cause damage in a young stand when live roots of susceptible trees contact *P. weirii* mycelium in diseased roots and stumps of the previous stand. After the infection is established on live roots, the fungus spreads along the root system, penetrating the bark, killing, and decaying the woody tissues. *P. weirii* must grow on wood, it cannot grow in soil. The fungus spreads to the root collar, around it, and out the other roots. The root contacts provide an extensive disease pathway within the stands (fig. 8). The disease pockets are estimated to expand 1 to 2 feet per year.

Laminated root rot creates understocked openings in stands by killing the trees. As these openings increase in size and age, a ''doughnut effect'' may become evident. Several feet behind the active edge of openings caused by laminated root rot, living trees may be absent. Closer to the center of openings seedlings may become reestablished. When the roots of susceptible seedlings contact diseased roots, they also become infected and the disease cycle is repeated (fig. 9). Trees tolerant or immune to attack may become established in the openings; if so, they will be considerably smaller than susceptible trees on the edges of openings.

In stands of poles and larger timber, the area occupied by infected roots extends beyond that indicated by crown symptoms. Trees with hidden infection may not display any crown symptoms until 50 percent or more of the root system has been killed. Crown symptoms may not be noticeable in poles and larger timber until 10 years after the initial infection. Tree death will usually occur within 5 years after symptoms develop. Susceptible trees that are within 15 feet of one killed by laminated root rot are usually infected. As the distance from the closest killed tree increases, the percentage of infected trees decreases. At 50 feet, infection from the same source is rare (fig. 10).

Planting susceptible species on untreated, infested sites will increase the amount of inoculum, causing damage to increase with each rotation. The seriousness of the damage will increase in direct proportion to stocking density and promptness of planting after harvesting since these factors influence root contacts and the time required for healthy roots to contact inoculum (fig. 11).

There is no published evidence to indicate that the disease is influenced by climatic, soil, or site factors; but environmental conditions favoring the growth of Douglas-fir and root contacts also favor *P. weirii.*

Figure 8. Disease spread.
The disease spreads when healthy roots contact infected roots.

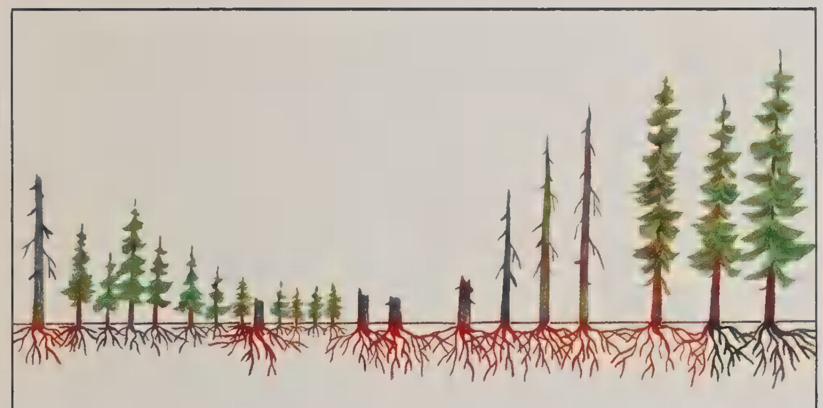

Figure 9. Doughnut effect.
Trees become re-established in the older portions of the infection centers. If they are susceptible, they will become infected when their roots contact the infected roots of the former stand of trees.

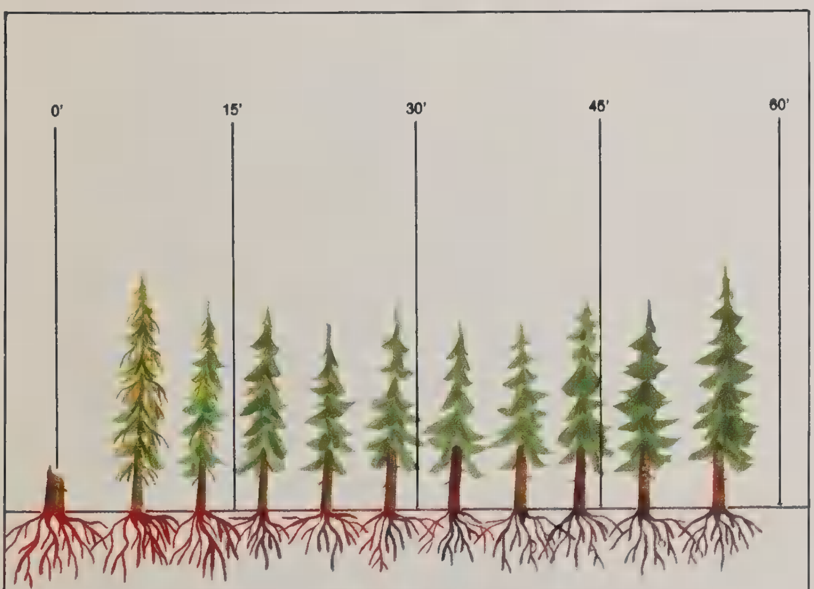

Figure 10. Hidden Infection.
Decayed roots are present on trees that do not show crown symtoms. All trees within 15 feet, or one or two normal tree spacings, of a dead tree are infected, but at 50 feet from the same source, infection is rare.

Host Susceptibility

Douglas-fir, mountain hemlock, grand fir, and Pacific silver fir are the most susceptible species and the most seriously damaged by laminated root rot. If these species are planted on untreated, infested sites, they cannot be raised to maturity without serious losses.

Western hemlock, subalpine fir, Sitka spruce, Engelmann spruce, and western larch are intermediate in susceptibility to laminated root rot. They can be infected when they grow in close association with the most susceptible species. They are seldom damaged if they are not growing in association with the most susceptible species. If these species of intermediate susceptibility are planted on infested sites formerly occupied by the most susceptible species, some losses will occur. Western hemlock is somewhat of an exception; it appears to be almost as susceptible as Douglas-fir when it is mixed with infected Douglas-fir of similar age in the stand, but it often remains healthy when present as a younger understory. Western hemlock suffers more butt rot than root rot.

Lodgepole pine and western white pine may be infected when they are growing in association with the most susceptible species. They appear to be tolerant of the disease and are seldom seriously damaged. They are rarely infected unless they are growing in association with the most susceptible species.

Ponderosa pine, western red cedar, and incense cedar are rarely damaged by laminated root rot in Oregon and Washington. *P. weirii* is an important cause of butt rot of western red cedar in the northern Rocky Mountains but windthrow and tree killing are rare. Mycelial development on cedar roots is very limited.

All hardwoods are immune to the disease.

No information is available on the susceptibility of noble fir, white fir, Shasta red fir, sugar pine, and redwoods.

Table 1.
Susceptibility of Pacific Northwest Tree Species to Laminated Root Rot

Susceptible	
Pacific silver fir	Abies amabilis
Grand fir	Abies grandis
Douglas-fir	Pseudotsuga menziesii
Mountain hemlock	Tsuga mertensiana
Intermediately susceptible	
Subalpine fir	Abies lasiocarpa
Western larch	Larix occidentalis
Engelmann spruce	Picea engelmanni
Sitka spruce	Picea sitchensis
Western hemlock	Tsuga heterophylla
Tolerant	
Lodgepole pine	Pinus contorta
Western white pine	Pinus monticola
Resistant	
Incense cedar	Libocedrus decurrens
Ponderosa pine	Pinus ponderosa
Western red cedar	Thuja plicata
Immune (hardwoods)	
Bigleaf maple	Acer macrophyllum
Red alder	Alnus rubra
Pacific madrone	Arbutus menziesii
Tanoak	Lithocarpus densiflorus
Cottonwood	Populus spp.
Poplar, aspen	Populus spp.

Management Recommendations

Recommendations for reducing laminated root rot losses must take into consideration distribution and severity of the disease, stand age, tree size and species, and site. Many small disease centers scattered through a stand are a more serious deterrent to sustained timber productivity than a few large centers because they present more infested perimeter from which the fungus can spread outward. Either clearcutting and planting with disease resistant conifers or hardwoods, or stump and root removal must be considered seriously where the disease is well distributed and spread appears to be rapid. Planting these untreated sites with susceptible species will result in serious losses. In stands with only a few small infection centers, the most appropriate decisions in some cases may be to ignore the disease.

WHAT WILL NOT WORK

No method of direct chemical control is known. Fumigation of infection centers with gaseous sterilants is considered impractical because of the difficulty of accurately defining the limits of the infection and the high costs of treatment. Applications of nitrogen fertilizers in amounts as high as 2,000 pounds of available nitrogen per acre have failed to inhibit growth of the fungus on roots.

Broadcasting burning, even with hot fires, will not create temperatures high enough to kill the fungus in buried roots.

Partial cutting or clearcutting will not control the disease because the fungus grows on recently killed roots and persists for many years in large roots and stumps.

Breeding Douglas-fir with resistance to laminated root rot offers little promise because no immune tree has been found.

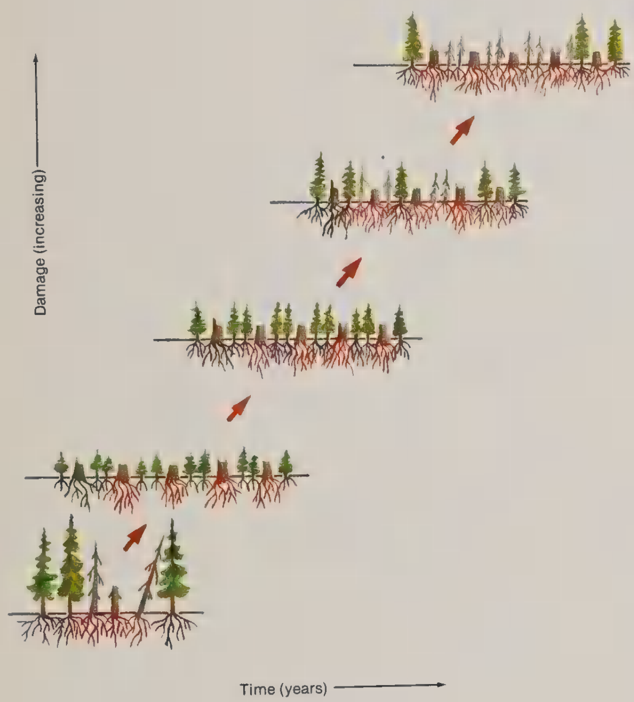

Figure 11. Planting susceptible species on untreated, infested sites will result in an increase of damage with each rotation.

Wide spacing to avoid root contact is not a practical solution because the spacings would have to be so wide that stocking would be unacceptably low and wood quality would be reduced. Natural regeneration would tend to fill in the unstocked areas and create numerous root contacts to spread the disease.

WHAT WILL WORK

The most economical and practical solution in many cases is to reforest diseased sites with tree species that are not susceptible to serious damage by laminated root rot. Fortunately, most sites in Oregon and Washington are capable of producing good growth on several tree species, so foresters will usually not be limited to one.

Table 1 lists the susceptibility of Oregon and Washington's commercially important tree species to laminated root rot.

Susceptible Group— These species should not be planted within 100 feet of a disease pocket. If they are, losses to disease will be at least as serious as in the previous stand.

Intermediate Group— These species may become infected, but usually they do not suffer serious damage unless they are growing in association with susceptible species. If pure stands of the intermediate species are planted on a site containing infected roots of susceptible species, some losses may occur; but it will probably be possible to grow them through a normal rotation without serious losses. Planting of intermediate species may allow the fungus to persist on a site since their roots can become infected. Their roots may also provide a disease pathway to adjacent susceptible species. West of the Cascades, Sitka spruce and western hemlock could be planted in disease pockets instead of Douglas-fir. In the higher elevations of the Cascades, Engelmann spruce and subalpine fir should be favored over the more susceptible Pacific silver fir, Douglas-fir and mountain hemlock. East of the Cascades, Engelmann spruce and western larch should be selected instead of grand fir or Douglas-fir.

Tolerant Group— Lodgepole pine and western white pine can become infected if they are growing in close association with infected susceptible species. Even though they may become infected, they usually are not seriously damaged. Where they are silviculturally adapted to an infested site the tolerant species should receive preference over susceptible and intermediate species.

Resistant Group— Conifers in the resistant group are rarely damaged by laminated root rot. If pure stands of resistant conifers are maintained in disease pockets, *P. weirii* will gradually die out over a normal rotation. West of the Cascades, western red cedar and incense cedar can be safely grown in laminated root rot centers where Douglas-fir has been damaged. East of the Cascades, ponderosa pine and incense cedar should be used.

Immune Group— Hardwoods are immune to infection by *P. weirii*. If they are adapted to the site, they could be grown instead of susceptible conifers. Hardwoods would probably have to be grown for a minimum of 40 years on a site formerly occupied by large infected trees before it would be safe to replant with susceptible conifers. It would take about that long for most of the infected roots from the former conifer stand to decompose and for the *P. weirii* to die out.

Red alder deserves special attention as a tree species to be used for reforesting laminated root rot pockets. Red alder can convert atmospheric nitrogen to forms available to many plants. Nitrates produced by red alder cannot be utilized by *P. weirii* but can be used by other soil organisms, some of which are antagonistic to *P. weirii*. For this reason *P. weirii* may die out faster in an infested site if alder is present than if some other hardwood species occupies the site. Mixed plantings of red alder and susceptible conifers in infested sites will not protect the susceptible conifers because the conifer roots will contact the infected roots from the previous stand before *P. weirii* has died out. Pure stands of red alder established in infection centers will prevent the disease from spreading to adjacent susceptible conifers.

The infection centers can be taken out of timber production and converted to grass or brush. After approximately 40 years, these areas could be replanted with susceptible species.

Mechanical removal of infected stumps and large roots will be effective in reducing the root rot hazard to future stands. The effectiveness of this approach depends on the volume of infected wood left in the soil after treatment. Tractors equipped with soil-ripping teeth that can penetrate up to 3 feet into the soil will bring large roots to the surface. A splitter attachment allows easier handling of large stumps. Well-decayed roots and smaller roots will be broken by the soil rippers and may not be brought to the surface. The broken roots will decompose faster than intact roots and should not present a serious source of inoculum. It is not necessary to remove the roots and stumps, brought to the surface, from the planting area because the fungus cannot grow through soil to infect roots. After a thorough stump and root removal treatment, it should be possible to raise a crop of susceptible species, such as Douglas-fir, to rotation age without serious losses. Some losses may still occur since the fungus might survive in occasional broken root pieces and infect healthy roots contacting them; however, such losses would be small.

Potential losses can be avoided by harvesting infected stands early. This practice will not control the disease unless follow-up treatments such as root and stump removal, or reforestation with less susceptible species, are applied to the site. Disease spread may, in fact, increase slightly for a short time because the fungus can move through recently killed roots faster than in live roots. Early harvest of infected stands is beneficial from the standpoint that recently killed trees and living infected trees will be salvaged before they become too deteriorated for wood product conversion.

Stand Treatments

The following management recommendations are presented by tree size classes from saplings, to poles and small sawtimber, to large sawtimber, and to recently harvested stands. In all cases, the treatments described are intended for stands in which species most susceptible to laminated root rot are, or recently have been, present. Foresters can take action to reduce losses from laminated root rot at each stage of stand development. Regardless of the stage of stand development, it is essential that foresters know how to recognize laminated root rot if reduction or prevention of losses is a management goal.

Treatments for Sapling Stands

1. Examine stands when the average tree height reaches 10 to 15 feet, or diameter is 1 to 2 inches at breast height. Information is most efficiently gathered during routine examinations prior to precommercial thinning. Symptoms of laminated root rot begin to appear in stands 10 to 15 years of age. At this stage of stand development, only individual scattered trees will be visibly affected; whereas in older infected stands, groups of trees will be affected. Stumps from the previous stand should be examined for decay from laminated root rot. If laminated root rot is present, map the concentration of diseased trees and stumps. Record whether the infested areas are few or numerous, scattered or concentrated.

2. Record the data in a permanent record where they can be readily retrieved.

3. If the disease centers are numerous and evenly distributed over most of the stand, do not do any stand improvement work. Infected stands of saplings can usually be grown to harvestable small poles before losses become severe. The following assumptions should be considered before investing time and money for timber stand improvement in infected sapling stands:

   a. The actual area of infection probably extends about 30 to 35 feet beyond trees and stumps with visible symptoms.

   b. The disease will spread about 2 feet per year from the edge of the infestation.

   c. The number of trees affected doubles every 15 years.

When infection centers are not numerous, the following treatments would be appropriate during timber stand improvement work in sapling stands.

1. Favor disease-resistant conifers, hardwoods, tolerant, and intermediate conifers in this order, in disease pockets, including those within 50 feet of visibly affected trees and stumps (fig. 12). The disease pockets should be clearly marked to aid thinning crews.

2. In cases where there are only a few disease pockets but they are especially active, it may be desirable to patch-cut all susceptible trees in the pocket and within 50 feet of trees or stumps visibly affected with laminated decay. Replant openings with resistant or tolerant conifers or hardwoods which are adapted to the site. This isolates the disease in the center and allows the infected root systems to decompose while they are small.

Treatments for Pole and Small Sawtimber Stands

1. Examine stands for laminated root rot and map the location of disease centers. Record the information in a permanent record where it can be readily retrieved.

2. In stands where the disease is not severe the healthy parts of the stand can be thinned as usual, but disease pockets should be identified and treated differently. Several alternative treatments could be applied to the pockets.

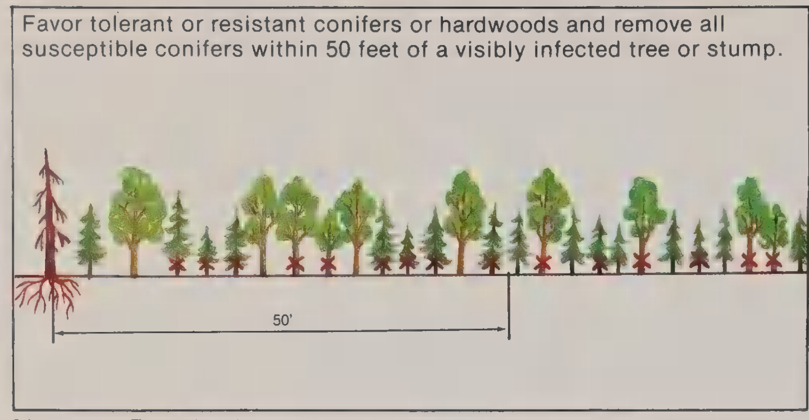

Figure 12. Thinning in sapling stands favor tolerant and resistant tree species.

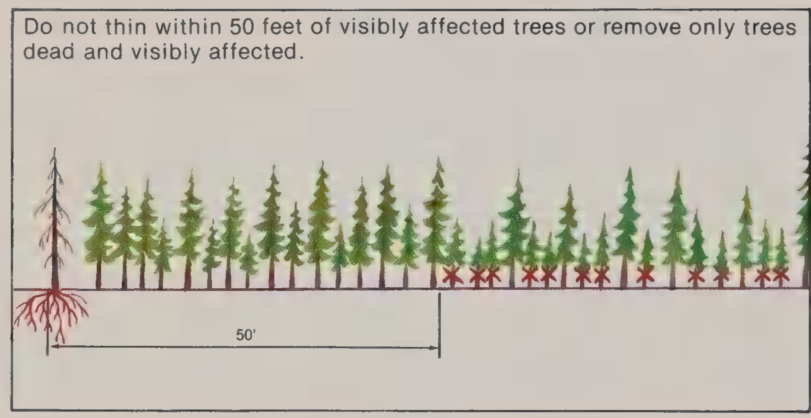

Figure 13. Do not thin within 50 feet of infection centers in pole and small sawtimber stands.

a. Do not cut any trees within 50 feet of the edge of disease pockets (fig. 13). This will not stop or delay spread of the disease but will result in less windthrow than if the entire stand is thinned because closed crown canopies provide some protection of individual trees from wind. Infected trees with green crowns have a high probability of being windthrown if surrounding trees are cut.

b. When stands can be entered at 5-year intervals, salvage dead and visibly affected trees. Most living trees with crown symptoms will die within 5 years.

c. If stand entries are limited to 6- to 10-year intervals, harvest all dead and visibly affected trees plus all susceptible species within two to three normal tree spacings, or within 20 to 25 feet of visibly affected trees.

d. If stand entries cannot be made at less than 10-year intervals, remove all visibly affected trees and all susceptible species within 30 to 40 feet of the visibly affected trees.

The treatments described in b, c, and d (fig. 14; will not, in most cases, stop spread of the disease. Their purpose is to salvage current and potential mortality while the trees still can be used for merchantable products. The wide barriers from which susceptible tree species have been removed will delay spread of the disease outward from the pockets. These treatments should also be of value in reducing the risk of bark beetle attacks in diseased stands since infected weakened trees will be removed.

Disease distribution must be considered when deciding whether to thin. Foresters should assume that in pole and small sawlog-size stands most susceptible species within 30 feet of a visibly affected tree will have decayed roots and will be windthrown if the stand is thinned.

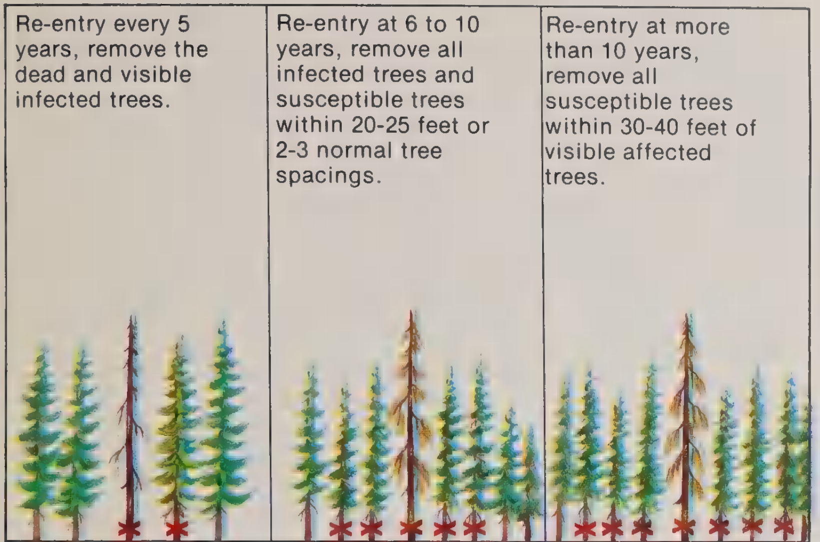

Figure 14. Thinning and salvage cutting cycles in pole and small sawtimber stands.

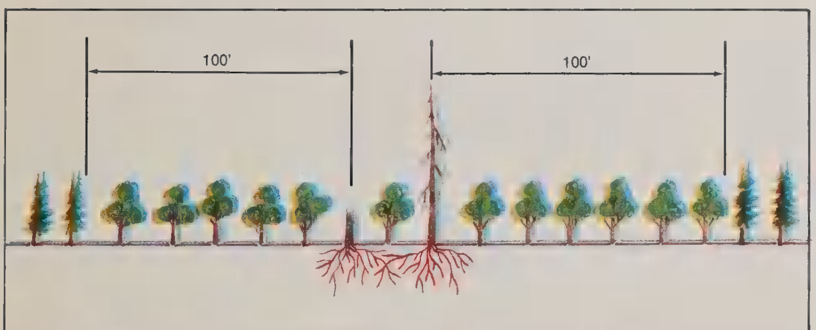

Figure 15. Do not plant susceptible conifers within 100 feet of infection centers. Plant only resistant conifers or hardwoods within 100 feet of infection centers.

3. Do not thin severely infected stands with numerous, well-distributed disease pockets. Susceptible and intermediate trees within 15 feet of a visibly infected tree are usually infected, but may not show disease symptoms. If the trees with hidden infection are kept as crop trees, they will soon be windthrown because their decayed roots will not support them.

4. Clearcut infected stands earlier than normally planned where the net volume increment is below the minimum acceptable level. Treat the clearcut site as described in the section on *Treatments After Final Harvests*.

Treatments for Large Sawtimber Stands

1. Map the disease centers during sale layout. It is often easier to locate disease centers at this time than after the stands have been harvested. Identify disease pockets in the stands by marking affected trees at the root collar with a tag or suitable identifying symbol that will remain visible after logging and slash burning. Record information on disease distribution in a permanent record for easy retrieval.

2. Clearcut the infected stands if the net volume increment is below the minimum acceptable level. Where terrain, size of trees, and other conditions permit, reduce the volume of infected root wood in the soil of infection centers by pushing out stumps or pushing over whole trees. Stump splitting attachments for tractors may be helpful for treating large stumps. In some sites it may be practical to remove stumps with explosives. Avoid burying large pieces of infected wood during logging. Treat the clearcut site as described in the next section.

Treatments After Final Harvests

This is the most effective time to actually control laminated root rot so that it will not be a problem in future stands to be grown on the site.

1. Mark disease pockets for machine operators or tree planters by painting or tagging infected stumps. Infected stumps can be identified by the characteristic reddish-brown stain or laminated decay in the stump top. Ideally, stumps should be examined for stained wood within 2 days after they are cut because the stain fades rapidly when exposed to air.

2. Where terrain and economics allow, remove all stumps and major roots in the infection centers and within 50 feet of an infected stump. Replant the area with any species adapted to the site.

3. If stumps and roots are not removed, plant disease pockets and a 100-foot-wide surrounding band with resistant or tolerant conifers or with hardwoods that are adapted to the site (fig. 15). Intermediate species could also be planted. Intermediate species can become infected and allow the fungus to persist on the site but disease losses should not be serious. If resistant conifers or hardwoods are planted and susceptible species are not allowed to become established, *P. weirii* will gradually die out.

4. Consider planting grass or allowing brush to develop in the disease pockets if no species other than susceptible are available or suitable. This approach may be useful where openings for wildlife are needed.

5. Do not plant disease pockets with susceptible species unless the pockets are so small and few or difficult to treat that the cost of treating them differently from the remaining portion of the stand would exceed the value of damage expected from the disease.

6. Examine the plantings at frequent intervals to monitor success of treatment.

Treatments for Intensively Used Sites

Trees with laminated root rot pose a serious potential hazard to permanent structures and people. Infected trees are especially prone to windthrow.

1. Consult forest pathologists when any root rot is suspected or has been identified in campgrounds, picnic sites, or near buildings that could be struck if the trees fell. Recommendations for or against the removal of suspect trees can be made after a thorough evaluation of the site.

2. Do not locate new developments within or adjacent to areas affected by root rot.

3. Schedule and conduct annual evaluations of potential hazard trees in high-use areas such as campgrounds.

These recommendations proposed for stands in various stages of development were designed to be used as general guides for foresters. Foresters must recognize that the prescription for a particular stand or management unit will depend on an evaluation of disease potential, management intensity, and goals.

Additional Information

Additional information and training on laminated root rot is available on request from the following agencies:

U.S. Forest Service
Forest Insect and Disease Management
P.O. Box 3623
Portland, Oregon 97208

Oregon State Department of Forestry
2600 State Street
Salem, Oregon 97310

Washington State Department
of Natural Resources
Division of Forest Land Management
Olympia, Washington 98504

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